Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 078-B**

How does Iron Protect Wild Rice from Sulfate?

Category: B. Water Resources

Total Project Budget: $ 401,142

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

Iron in sediments is protective of wild rice, but only partially. Our study will determine the balance of beneficial and harmful effects of iron on the sustainability of wild rice.

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Sponsoring Organization: U of MN - Duluth

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Iron is thought to protect wild rice ecosystems from sulfate. But it appears to be only partially protective. Part of the reason might be that when sulfate is introduced into the ecosystem, roots develop black iron sulfde coatings, whereas wild rice roots are naturally orange. Our study will determine the balance of beneficial and harmful effects of iron on the long term sustainability of wild rice populations.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: How does iron protect wild rice from sulfate?

I. PROJECT STATEMENT

Background:

The state of Minnesota has been grappling with the need to meet stringent water quality standards to protect wild rice in rivers and lakes. A variety of industries across the state, including mining operations, wastewater treatment plants, and coal-fired power plants, emit sulfate in water discharges that have the potential to harm wild rice. The state of Minnesota has invested significant resources in quantifying an appropriate sulfate limit for protecting wild rice. Our team was involved with the MPCA wild rice study; the questions we propose to answer here arose during that study. Iron in sediments is believed to be protective of wild rice, but evidence suggests that it may be only partially protective (see graphic). Early in the growing season, iron protects young wild rice seedlings from the harmful effects of elevated sulfate. But later in the growing season, seed production is impaired on mature plants with black iron sulfide coatings on roots. Our study will determine the balance of these beneficial and harmful effects of iron on the long term sustainability of wild rice populations.

We will combine *experimental observations* on thousands of individual wild rice plants and dozens of reproducing wild rice populations with *field observations* in 10 natural wild rice lakes and streams to evaluate and document the role of iron in maintaining sustainable, healthy wild rice populations. We will synthesize our results into a *mathematical model* to describe how iron impacts wild rice growth in the presence of sulfate. Additionally, a guide to the effects of sulfate and iron on wild rice sustainability will be distributed to state, tribal, and federal land managers to help manage wild rice on a sound scientific basis.

Wild Rice covers 100 square miles of area in over 1200 MN lakes. It provides essential habitat for migrating and nesting waterfowl and serves as a cultural and economic resource for native peoples and recreational harvesters. Millions of pounds of wild rice are harvested each year in the state of Minnesota. The research supporting a proposed adaptable standard by the MPCA has positioned Minnesota at the forefront of science-based management related to the topic. The state's proposed standard recognizes the complex interactions between sulfate, iron, and aquatic plants discovered during the course of these previous experiments. Our study will build upon this prior research to help provide an understanding of the interactions among sulfate and iron in the rooting zone of wetland plants that can form the basis for an effective approach to regulating sulfate discharges.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Experimental observations*- Evaluate and document effects of iron and sulfate on wild rice growth and seed production **Budget: $174,867**

We will test the effects of iron and sulfate on wild rice in a variety of experiments including some long-term population experiments. Tests on hundreds of individual wild rice plants grown with and without sulfate and with and without iron will help to understand the effects on both seedling survival (in spring) and seed production (in fall). The longer-term experiments that were initiated 4 years ago with the MPCA will help to understand the long-term sustainability of rice in the presence of iron and sulfate. We will measure iron and sulfate in sediments and on wild rice roots and document the development of black root coatings. We will also measure the health of plants in terms of their growth and reproduction. We will continue to communicate the results of our research to MPCA staff and seek their advice on the design of these experiments.

Outcome	Completion Date
1. Evaluate and document the effect of iron and sulfate on *individual wild rice plant health*	Jun 2020
2. Evaluate and document the effect of iron and sulfate on *sustainable wild rice populations*	Jun 2020

Activity 2: *Field observations*-Evaluate effects of iron and sulfate on rice in lakes and rivers Budget: $166,562

We will document the health of wild rice in natural lakes and streams with a range of iron and sulfate contents in order to verify that the interactions among sulfate, sediment iron, and plant health occur similarly to observations made in experimental studies (Activity 1). We will sample 10 lakes and streams including Big Sandy Lake, Lake Itasca, and the Mississippi River in order to obtain a variety of natural conditions expected to support healthy wild rice. We will work with MPCA and DNR to select the specific locations.

Outcome	Completion Date
1. Document sulfur and iron accumulation on wild rice roots in lakes and streams	Jun 2020
2. Validation of experimental observations with field measurements	Jun 2020

Activity 3: *Mathematical modeling*- Using experiments and field observations to create a model of iron and sulfate's impact on wild rice Budget: $59,713

We will use the results of our experimental and field measurements to develop a model describing the interactions among plant roots and sediment iron and surface water sulfate. The modeling will help us extend the results of our experimental observations to different conditions across the state. We will seek advice from MPCA about the development of our model in Activity 3 and will make this model available to MPCA staff to assist them as they move forward in developing water quality standards for wild rice.

Outcome	Completion Date
1. Model of iron and sulfate in natural lake and stream based on experimental results	Jun 2021
2. Evaluation of the role of iron in maintaining wild rice health	Jun 2021
3. Develop a guide of wild rice sustainability for dissemination to statewide interest groups	Jun 2021

III. PROJECT STRATEGY

A. Project Team/Partners

Our multidisciplinary team, consisting of Dr. Nathan Johnson (PI), and Drs. Daniel Jones and John Pastor (Co-PIs), has a history of working with state resource managers, Native American tribes, and industrial partners to help solve issues related to water quality and resource management. Johnson is a Civil Engineering professor at the University of Minnesota Duluth and expert in sulfur and iron chemistry. Johnson will lead efforts to measure the sulfur and iron content of roots and sediment in Activities 1 and 2 and be responsible for developing the model in Activity 3. Jones is a Research Associate in the University of Minnesota BioTechnology Institute and Department of Earth Sciences and an expert in microbial ecology and biogeochemistry. Jones also serves as an industry liaison for the University of Minnesota. Jones will characterize microbe-root interactions that affect sulfate and iron chemistry in Activities 1 and 2. Pastor is a Biology professor at the University of Minnesota Duluth with expertise in plant nutrients who will oversee the experiments in Activity 1.

B. Project Impact and Long-Term Strategy

This research could help protect over 100 square miles of wild rice on over 1200 lakes in Minnesota which yield millions of pounds of rice each year and provide at least $500,000 of revenue for tribes. Either over-protection or under-protection of wild rice lakes and rivers could cost tens of millions of dollars and have significant legal ramifications. The results of the proposed project will be put into a usable guide and distributed to staff at state agencies who make policies related to water quality standards and permit industrial discharges. Results will also be published in peer reviewed journals to receive critical feedback and as a means of dissemination to a wider audience.

C. Timeline Requirements

The project will be completed in 3 years starting in July 2018, completed by June 2021.

2018 Detailed Project Budget

Project Title: Understanding sulfur-root interactions to protect wetland ecosystems

INSTRUCTIONS AND TEMPLATE (1 PAGE LIMIT)

Attach budget, in MS-EXCEL format, to your "2018 LCCMR Proposal Submission Form".

(1-page limit, single-sided, 10 pt. font minimum. Retain bold text and DELETE all instructions typed in italics. ADD OR DELETE ROWS AS NECESSARY. If budget item row is not applicable put "N/A" or delete it. All of "Other Funds" section must be filled out.)

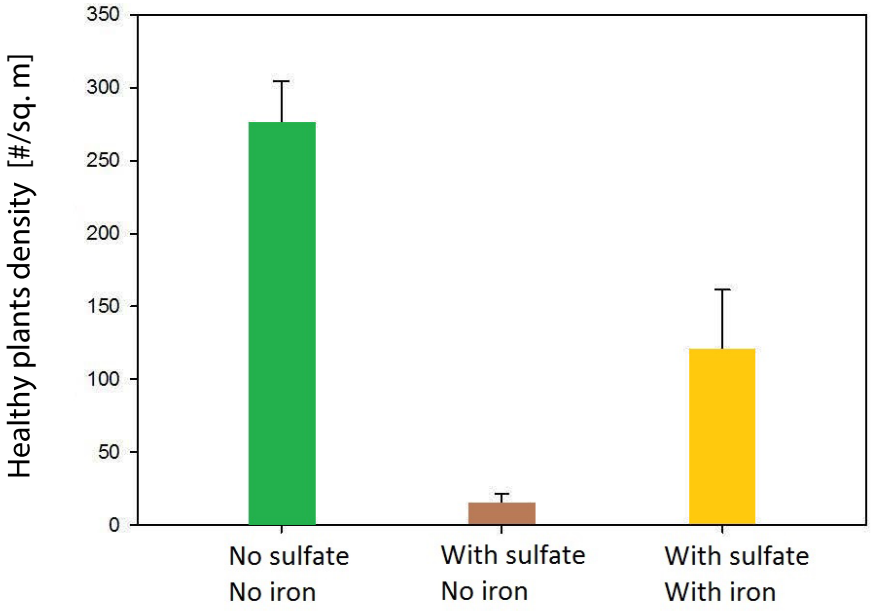
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM *(See "Guidance on Allowable Expenses", p. 13)*	**AMOUNT**	
Personnel:		**$ 338,985**
Bradley Dewey, technician (100% FTE, 33.7% fringe, 2 yrs).	$	173,722
Sophie LaFond Hudson (graduate student, 100% Research Assistantship, 16.9% fringe, tuition 2 yrs)	$	88,836
Laboratory technician (0.25 FTE, 2 yrs, 25% of salary, 26% fringe, 2 yrs), to work with Jones	$	44,513
Undergraduate students (3 students, summer support, 0% fringe)	$	31,914
Equipment/Tools/Supplies:		**$ 46,169**
Materials and Supplies for field and lab	$	30,212
Analytical laboratory costs for biological and water analyses.	$	15,957
Travel:		**$ 10,865**
Mileage, lodging,and meals for travel to and between Minneapolis and northern Minnesota field sites	$	10,865
Additional Budget Items:		**$ 5,123**
Publication costs and document dissemination	$	5,123
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$**	**401,142**

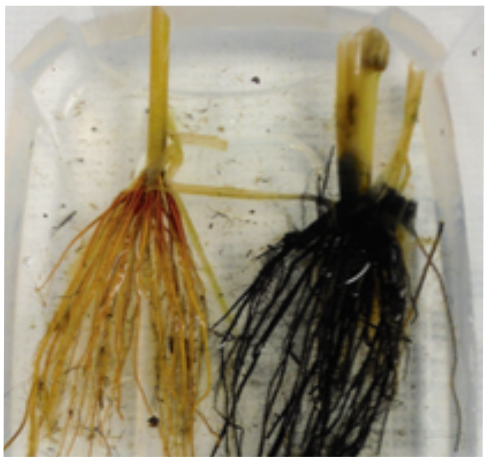
V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS		
Other Non-State $ To Be Applied To Project During Project Period	N/A	N/A
Other State $ To Be Applied To Project During Project Period	N/A	N/A
In-kind Services To Be Applied To Project During Project Period: Jones is not requesting any salary, and will use 2 mo./year of his time as cost-share to the project (16.7% of his total salary and benefits). The University of Minnesota does not charge the State of Minnesota overhead (54%; estimate is based on total direct costs excluding graduate student tuition and salary).	$ 243,952	*Secured*
Other Funding History: NSF SUPPORT to J. Pastor (DEB-0211691, 9/15/2002-6/31/2006, Wild rice population dynamics and nutrient cycles, and DEB-0715808, Wild rice population oscillations, allocation patterns, and nutrient cycles, 8/01/2007-7/31/2011); Minnesota Pollution Control Agency, (Wild rice sulfate standards study, 9/1/2012-1/31/2014); Minnesota Sea Grant (The biogeochemical habitat of wild rice 3/1/2014-6/31/2016); Fond du Lac Band of Lake Superior Chippewa, (The biogeochemical habitat of wild rice – supplemental grant, 9/1/2012-1/31/2014)	$ 1,541,611	
Past and Current ENRTF Appropriation:	N/A	N/A
	$ 1,785,563	

How does iron protect wild rice from sulfate?



Iron is thought to protect wild rice ecosystems from sulfate. But it appears to be only partially protective.



Part of the reason might be that when sulfate is introduced into the ecosystem, roots develop black iron sulfide coatings (right), whereas wild rice roots are naturally orange (left).

Our study will determine the balance of beneficial and harmful effects of iron on the long term sustainability of wild rice populations.

Project Manager Qualifications and Organization Description

Project Manager Qualifications. Our multidisciplinary team has a history of working with state resource managers, native American tribes, and industrial partners to help solve issues related to water quality and resource management. Dr. Nathan Johnson, the Project Manager, is a Civil Engineering professor at the University of Minnesota Duluth who will lead efforts to measure the sulfur and iron content of roots and sediment. Dr. Johnson will also be responsible for developing a model for the interactions among sulfur, iron, and organic matter and their effect on wild rice growth. Dr. Johnson will be assisted by Dr. John Pastor, a Biology professor at the University of Minnesota Duluth who will oversee the stock-tank experiments and assist in the pot experiments in Activity 1, and Dr. Daniel S. Jones, a Research Associate in the University of Minnesota BioTechnology Institute, with affiliate and graduate faculty status in the Department of Earth Sciences. Jones is an expert in environmental microbiology and microbial ecology. Jones also serves as an industry liaison for the University of Minnesota MnDRIVE initiative Advancing Industry, Conserving Our Environment.

Organization Description. The University of Minnesota is a public university and the state of Minnesota's land-grant university. In addition to the laboratory facilities available to the PIs, the university includes multiple core facilities (including the Characterization Facility, the University of Minnesota Genomics Center, and the Minnesota Supercomputing Institute) that have the equipment and instruments necessary for the proposed studies.